Healthy Lifestyle Solutions

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White Paper

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Executive summary

Interest in finding ways to improve health continues to increase. Traditionally, the majority of health-related research has been focused on clinical contexts and biomedical science, but there are significant gains to be made in finding ways to promote changes in health-related behaviours. Without denying the importance of finding a medical cure for diabetes or heart disease, for example, there is at least as urgent a need to find ways to help people in their efforts to adopt healthier lifestyles – lifestyles that reduce their risks of developing such medical conditions in the first place.

'E-coaching' is a particularly promising approach to this area. The field is focused on employing technologies to support individuals in their efforts to monitor and improve their health, whether on their own or as part of a treatment programme. Given the speed with which this field is developing and the highly personal nature of these technologies, there is a need for principles that can guide the design and implementation of effective and appropriate approaches to e-coaching.

The present white paper presents five such principles and discusses both their scientific underpinnings and their (potential) applications. The paper crystallises insights that have emerged in recent and ongoing research developed in the Healthy Lifestyle Solutions programme, which is co-ordinated by the Technology Foundation STW and jointly funded by Philips Research and NWO's National Initiative for Brain and Cognition. Those research projects are focused on the areas of diet, exercise, sleep, and stress, but their applications are even wider.

(A) Tailoring interventions: E-coaching strategies and devices will not succeed unless they are sensitive both to the contexts in which individuals need feedback and to individual differences regarding goals, starting positions and personality. Unobtrusive monitoring technologies are increasingly able to provide the requisite data, but having lots of data is not enough. The effective use of these data requires scientific insights into which factors are most relevant in determining when and how to provide which feedback.

(B) Securing trust: Precisely because effective e-coaching requires extensive monitoring and data collection, it is vitally important that users' trust in the devices, the software, and the companies providing support services is not jeopardised. Trust becomes even more crucial as users come to act upon advice from the e-coach. Moreover, because the automaticity of users' responses to e-coaches' advice is the key to effectively motivating users to do what they don't feel like doing (at that moment), the design of e-coaching systems must ensure that they are able to earn users' trust.

(C) Preparing for moments of weakness: Establishing and maintaining a healthy lifestyle requires resisting numerous temptations. E-coaching can help users to stay on track by supporting their efforts to identify and prepare for specific 'danger zones' *before* their willpower is compromised. In particular, 'if-then plans' and pre-programmed responses to negative thoughts have proven effective here, partly by reducing reliance on conscious decision-making in the moment.

(D) Engaging supportive (social) environments: Behaviour change doesn't happen in a vacuum. The success of efforts to adopt healthier lifestyles depends crucially on the sort of peer pressure and 'choice architecture' one faces. Effective e-coaching makes use of this by helping individuals to shape how options are presented and to take advantage of their *social* environment, through the use of social contagion, social norming, and social networks.

(E) Ensuring autonomy: Part of the appeal of e-coaching lies in the promise it holds for people who feel *out of control* with regard to their health behaviour. As a support structure, e-coaching can strengthen people's autonomy skills and help them lead their own lives. At the same time, hardly anyone likes to be bossed around and a nagging smartphone app is quickly deleted. In designing e-coaching, it is thus critical to provide assistance in a way that users can recognise as aligned with their aims and based on their efforts, rather than an external imposition.

Taken together, these five principles can serve to guide the development and implementation of devices and services that effectively and appropriately promote healthy lifestyles.

Introduction

This White Paper presents an overview of recent and ongoing research intended to inform the development of new products and services that help individuals develop and maintain the healthy lifestyles to which they aspire. The document is an expression of insights developed by researchers from the various projects in the Healthy Lifestyle Solution programme, which is co-ordinated by the Technology Foundation STW and jointly funded by Philips Research and NWO's National Initiative on Brain and Cognition. It is not a final summation, but rather a current snapshot that will invite further response from Philips Research as well as from those involved in product development and support at Philips.

The text is organised around five principles that have emerged within the research groups and in our joint conversations as being key principles for designing successful health promotion strategies and technologies. These are:

Principle A: Tailoring interventions (ThinkSlim project group, lead author: **Bastiaan Boh**): making sure that the e-coaching strategies/devices are sensitive to: (i) differences between users (e.g., personality, age, goals, relative health, recent behaviour, past successes/failures); (ii) differences between environments (e.g., alone vs. with friends; at home vs. in a restaurant; weekend vs. workday), and; (iii) differences in users' conditions (hot/cold states, fatigue, moods, cravings).

Principle B: Securing trust (SleepCare project group, lead author: **Robbert Jan Beun**): establishing and maintaining the user's trust. Product reliability and privacy protection are clearly part of this, but so is the importance of designing a human-machine interface that ensures that users do not become dismissive of e-coaching recommendations but feel comfortable relying on an e-coach.

Principle C: Preparing for moments of weakness (Promoting Effective Intentions project group, lead author: **Sanne Nauts**): anticipating situations in which intention-behaviour gaps loom large (principle "A") and then taking steps to ensure that users are able to take advantage of beneficial automaticity. Implementation intentions are a prime example of this, as are strategies for making available, at critical moments, supportive thoughts (CBT) or pre-programmed routines that reduce reliance on conscious decision-making.

Principle D: Engaging supportive (social) environments (Active2Gether project group, lead author: **Michel Klein**): shaping the 'choice architecture' regarding the way in which options are presented and by helping individuals to take advantage of their *social* environment, though the use of social contagion, social norming, and social networks.

Principle E: Ensuring autonomy romoting Effective Intentions project group, lead author: **Bart Kamphorst**): not only giving users control over the terms of their use of the e-coaching support (related to trust) but also the experience of being more in control of their lives – even if this is the result, paradoxically, of outsourcing some of their self-monitoring and self-steering to the assistive devices and services.

Each of the following sections is devoted to one of these principles, even while noting the interconnections between them. And in each section, we address the following six questions:

- Introduction to the principle: what does it entail?
- What is the state of the current research regarding these principles?
- What are the shortcomings in the existing research (shortcomings that HLS projects are addressing)?
- What are the results or new research techniques emerging in the HLS projects?
- What are some existing products/devices that already incorporate this principle (especially those related to exercise, sleep and nutrition)?
- What are some illustrations of potential applications of this research in Philips products and/or services?

Ecological questioning

‘Ecological Momentary Assessment makes it possible to identify moments at which intervention is needed most,’ says ThinkSlim project leader Anne Roefs from Maastricht University. Within the project, the researchers incorporate concepts from Cognitive Behavioural Therapy (CBT) into a smartphone app to help people change their eating behaviour.

‘We have monitored people’s eating habits during a two-week period,’ explains Roefs. ‘We were looking for variables that predict unhealthy eating behaviour. Participants were asked to answer questionnaires during eating moments and at random moments during the day. For example, at an eating moment, people had to describe their thought related to eating behaviour, their level of craving, and their emotions.’ This monitoring study led to some striking insights. ‘For example, we found that, contrary to the concept of “emotional eating”, the experience of negative emotions was not specific for eating moments in overweight people. Overweight people reported more negative emotions on unhealthy and healthy eating moments, as well as on non-eating moments, as compared to healthy-weight people.’

From the answers to the questionnaires, the project team extracted five profiles, each of which consists of a set of specific predictors of unhealthy eating behaviour. ‘In a follow-up study, each participant is matched to one of the profiles. CBT-techniques are used to challenge dysfunctional thoughts and the profile-information is used to send timed feedback. Beforehand, participants are asked to compose lists, for example of things they like to do, or reasons why they want to lose weight. The app uses this information to motivate them at weak moments to stop them from snacking. For example if from the profile it is known that someone tends to eat at night out of boredom or solitude, the app can send timed messages suggesting to pick an activity from the list of their favourite things.

With EMA you can gain more insight into people’s behaviour, emotions, and thoughts. If you know that, it is easier to intervene at times when someone needs it the most. And as soon as an app can do that, it has some advantages over a therapist. Advice is always available when you need it and for as long as you need it. It is not restricted to that one therapists’ appointment per week.

Principle A: Tailoring interventions

A.1 Key aspects of tailoring health-promoting interventions and strategies to users and their contexts

What is tailoring?

The process of tailoring is described in a variety of ways, but a solid operational definition is: "Any combination of information or change strategies intended to reach one specific person, based on characteristics that are unique to that person, related to the outcome of interest, and that have been derived from an individual assessment" (Kreuter, 2000, p. 1). This implies that tailoring is not dichotomous (tailored/not tailored) and can be applied to any number of relevant processes. In addition, 'tailoring' should not be confused with 'anything goes'. What needs to be tailored are nonetheless standardised treatment protocols, since research has shown that 'eclectic' treatment, wherein the therapist uses personal judgments to determine how to tailor a treatment fully (also in terms of therapeutic techniques and treatment progress), is less effective than treatment that follows a (rigidly) standardised protocol (Schulte et al., 1992). In this sense, the protocol serves as a robust framework for progress that has proven to be effective. Within the boundaries of such a protocol, tailoring to the day-to-day experiences of a client should be done as thoroughly as possible. Determining the effectiveness of tailoring an intervention is complicated, as it ideally optimises compliance, adherence, clinical effect sizes, costs, duration, tenacity of a condition (e.g. relapse), intensity of the intervention, and sensitivity.

The necessity of tailoring for effective interventions

Tailoring is not necessary if you want to change a simple or very strong and obvious relationship between some predictor and an outcome of interest. This is illustrated by the 'miracle pill' example: if we invent a pill that has no side effects and reduces undesired outcomes, we do not need to tailor its administration. We simply provide the pill and that is sufficient. However, psychological and behavioural problems are often complex. An undesired outcome is often the result of multiple small risk factors and causes. This can be summarised by looking at what exactly it means to have a psychological condition or disorder. Kendler (2011) argues that it is useful to define a psychological condition or disorder as a 'mechanistic property cluster' (MPC) of underlying causal and inferential connections between features of interest (i.e. affective states, thoughts, physiological determinants, geospatial networks, relevant events, etc.). It is specifically these connections that can give rise to dysfunction: an MPC (also referred to as a 'network') for a condition or disorder is characterised by much stronger potentially problematic relationships between features when compared to a non-disordered MPC. (For a reference on the construction of these networks, see Borsboom and Cramer, 2013.)

When we start defining conditions and disorders according to MPC principles, it quickly becomes clear that it is not sufficient to provide one identical tool to treat all people based, for example, on general criteria (such as the DSM V). Only by properly illustrating the MPC can we pinpoint the part of the cluster/network that requires intervention. This necessitates 'zooming in' on daily life at the appropriate level, both for assessment and intervention. For example, stress may be experienced in a social context, in a work environment, as an anticipatory state, etc. Not all of these instances of stress are necessarily disordered. Once we disentangle what is going on, we can more effectively intervene.

Goals for the intervention

The first step in designing an effectively tailored intervention, after determining the target of the intervention, should be investigating the literature to see what is already known about the different features/properties involved in a certain condition or disorder. For example, many cognitive, behavioural and physiological factors have been linked to overeating behaviour, most notably contextual cues in the environment (Swinburn et al., 2011) and person-specific factors such as impulsivity (e.g., Nederkoorn et al., 2006) and emotional eating (e.g. Macht, 2008). Such factors do not appear to be effectively characterised using catch-all tools such as questionnaires (Adriaanse et al., 2011; de Ridder, Adriaanse and Evers, n.d.; Evers, de Ridder and Adriaanse, 2009). It therefore would seem that an effective intervention must be tailored more rigorously to people's day-to-day experiences. Some people may have a problem inhibiting their responses to intake-predicting cues in the environment (i.e. they are more impulsive), while other people may have habitually established poor eating habits.

Similarly, some may overeat as a reward after accomplishing something positive, while others eat because they are bored.

How to tailor most appropriately

Next we need to decide how we should tailor by investigating suitable methods. To take the case of psychological treatment for weight management, tailoring interventions to interpersonal and intrapersonal variability is already part of best practices. For example, in cognitive behavioural therapy (CBT), the therapist and client investigate dysfunctional thoughts (e.g. "When I am a guest, it's rude to refuse food") in the context of day-to-day experiences and within the confinement of the treatment protocol. By tailoring CBT as closely as possible to what is relevant and believable for the client, very specific problematic behaviour can be targeted and changed (Beck, 2005). CBT is an appropriate starting point for tailoring an intervention designed to help people develop healthier eating habits. The main advantage of CBT is that it is compartmentalised in well-described modules of intervention techniques. Additionally, of all forms of therapy investigated, CBT has the strongest focus on tailoring (as it targets both cognitions and behaviour). Lastly, even if there is no uniform CBT protocol for weight loss, it is a very thoroughly investigated therapy form in the more general field of psychological treatment. With regard to different disorders, including eating disorders such as Binge Eating Disorder and Anorexia Nervosa (see for example Fairburn, Cooper, and Shafran, 2003), CBT treatment protocols and their theoretical rationale are strongly established and heavily investigated.

The problem is that, given the prevalence of obesity and the costs of traditional face-to-face client and therapist sessions, standard approaches to tailoring CBT will leave a large number of people without treatment. This problem is worsened by the requirement of having highly trained therapists available and the requirement of long-term or even indefinite treatment. In recent years, an interesting physical and mental health and therapy administration alternative, dubbed mHealth, has been emerging. mHealth makes use of mobile technology to improve treatment effectiveness. Although some methods for mHealth-related therapy include (limited) therapist contact, it is also feasible to consider the possibility of delivering completely automated therapy, that is, without any therapist contact. This paves the way towards treating even larger groups of people. Supporting evidence so far is still rather limited, especially for eating behaviour. However, research on depression and anxiety disorders indicates that such approaches are less effective than those that include a component of limited therapist contact, but still have a significant clinically beneficial effect (Cuijpers et al., 2011; Spek et al., 2007).

How will we implement our tailoring procedure?

Lastly, we need to determine how we would like to implement tailoring based on these ideas of cost-efficiency, wide reach and automation. An interesting methodology in this regard, which has been gaining attention in psychological research on overconsumption, is the method of 'ecological momentary assessment' (EMA) (Shiffman, Stone, and Hufford, 2008; Smyth and Stone, 2003), also often called the 'experience sampling method' (ESM). Stemming from diary-based observational research, EMA is informative regarding behaviour as it unfolds over time. By measuring and sampling at successive time points, a fine-tuned and more micro-level observational assessment is achieved. Zooming in on psychological and behavioural variables of interest enables researchers to account for idiosyncrasies that explain additional variance when compared to cross-sectional (laboratory) assessments (Myin-Germeys et al., 2009; Scollon and Kim-Prieto, 2003).

The methods for such assessments are continuously improving in applicability, relative to technological advancement (Shiffman et al., 2008). Most commonly, EMA makes use of specialised questionnaires that assess subjective momentary states several times per day, as determined beforehand by an experimenter (e.g., by asking 'How do you feel right now?', 'What are you doing right now?' or alternatively 'Since the last time you filled in this questionnaire, have you experienced a hallucination?').

As smartphone use is very prevalent in society, it makes sense to use this device to gather relevant data using the EMA methodology. We can then use these data to provide automated, tailored CBT to achieve weight loss and/or reach healthier eating habits. Such a form of therapy is called an 'Ecological momentary intervention' (Heron and Smyth, 2010).

A.2 The current state of research

Firstly, the *emerging field of persuasive technology* is increasingly emphasising the importance of suitable personalisation and tailoring (see Kaptein, 2010; Masthoff, Grasso and Ham, 2011). Research on persuasive technology discusses strategies for persuading, motivating and influencing people, with extensive attention to tailoring, for example in connection with serious gaming (Orji, Vassileva and Mandryk, 2014) and health message framing (Dijkstra, 2014).

Secondly, the *use of smartphones and EMA* is an emerging field of science for assessment of a wide variety of psychological and physiological variables and mechanisms. This field is continuously extending in parallel with technological developments (i.e. smartwatches, Google Glass, virtual reality environments, GPS, pedometry, sensors for measuring physiological signals). Increased technological mobility and more measurement options mean that tailoring is able to focus on an increasingly broader scope of predictors.

The *statistical methodology* applied in this field of research is also under rapid development. Some examples:

- As a result of measuring from moment to moment, change over time itself also becomes a relevant novel factor in explaining group differences (Kuppens, Oravecz, and Tuerlinckx, 2010).
- Recent efforts into analysing and interpreting momentary interrelations between variables have begun investigating the concept of networks that characterise how well variables on one time point are able to predict scores of other variables, or even to predict the same variable in the network on a successive time point (Borsboom and Cramer, 2013; Bringmann et al., 2013). This is a very interesting approach that refers directly back to the MPC approach discussed earlier. By looking at interrelations of variables, a model of risk contingencies can be established to enable intervention even before an event occurs (e.g., if being bored on one time point can predict eating a snack on the subsequent time point of assessment, this means that boredom is (for this person) a risk factor for overeating).

Lastly, research on *EMIs* (interventions based on EMA data) is also emerging. There are currently two main approaches for EMIs:

- A summary of the momentary changes of certain relevant variables over a given period can be provided as detailed graphical feedback (Wichers et al., 2010, 2011). For example, feedback could indicate that “being at home” is usually indicative of reporting negative emotions, while “being in the company of others” is indicative of positive emotions. At the same time, “being in the company of others” may only occur in a small percentage of total reported circumstances, leading to a conclusion that it may be beneficial to increase the amount of time spent in the company of others. Such feedback can be an effective complement to regular therapy (Kramer et al., 2014).
- Going beyond merely providing feedback, computational algorithms (Markov chains, sequential pattern mining) and network analyses (as shown previously) could make predictions of risk contingencies: if a certain pattern of feature relationships in an MPC often emerges prior to an event that the intervention aims to target (for example: snacking), this information can be used to predict when such an event will occur. The EMI can then intervene prior to the event having taken place.

Therapeutic techniques and principles adapted from existing treatment protocols can be implemented into an EMI apparatus or programme (Heron and Smyth, 2010). This is essentially an extension of automated internet-based interventions (i.e. without therapist involvement) to include a more tailored look at daily life by making use of data gathered using EMA principles. Evidence is emerging that such an intervention is well-accepted by clients and can be successfully applied to treat a wide variety of symptoms (Heron and Smyth, 2010). Because EMIs do not involve (as much) therapist contact, and because there is no ’end’ to an intervention, the EMI can be used indefinitely. Another major advantage is that intervening can occur right when it matters (Heron and Smyth, 2010).

A.3 Gaps and opportunities in the existing research

The HLS projects are at the forefront of an emerging crucial field of research that combines intervention options with mobile technology. This field of research addresses the following aspects:

- Applicability of interventions and tailoring in terms of cost-effectiveness and scope (i.e. reaching the appropriate target audience). The ThinkSlim project is currently setting up an intervention study, using a mobile phone application to provide therapy to people who are seeking to live a healthier life by changing eating behaviour. While estimating cost-effectiveness is not the direct purpose of the study, it opens the avenue for future research projects to investigate this role in more detail. Such an investigation could compare the cost reduction resulting from having no therapists involved to the relative effectiveness in terms of health behaviour gains. There is already some evidence that e-Health results in cost reductions over regular therapy, for example with regard to alcohol abuse (e.g. Smit et al., 2011).
- Gaining insight into people's daily lives without relying on retrospective questionnaires (which can run into problems with memory bias) and without necessitating personal contact with a therapist (who might not even be available).
- Making use of a risk assessment framework (mechanistic property clusters) that emphasises relationships between properties/features that together form a 'cluster' that represents a certain condition or disorder. This moves away from the DSM way of defining conditions/disorders, but emphasises that it is essential to look at each cluster separately on the level of the individual, because such an assessment is necessary in order to achieve stronger tailoring, even within the constraints of a treatment protocol.
- Helping people directly when and where it matters by providing an intervention that is accessible 24/7 (i.e. providing feedback and prophylactic warnings).
- Designing an intervention that models the risk structure of a condition or disorder and is able to provide therapy 'in the moment'. Not much work has been done in this respect, particularly in the areas of eating behaviour and healthy eating. We do not know which behaviours are problematic on the level of the individual (Carter and Jansen, 2012).
- In the SleepCare project (Beun, 2013), it was found that sleep restriction exercises should be tailored by including an explicit negotiation stage (between coach and client). At this stage, the coach determines which variables are most important to the client and how they should be incorporated in the exercises. For example, duration and quality of sleep are highly variable and personal, and thus need to be accounted for appropriately.

A.4 Results and insights emerging in HLS projects

ThinkSlim has recently completed data collection for a large EMA study. In this study, over a period of 2 weeks participants used their iPhones to report mood, craving, location, activities, eating events, and thoughts related to those events. These data allow us to construct the aforementioned MPCs (networks) of relationships between these variables, using statistical and computational modelling techniques such as vector autoregressive analysis and sequence analysis. We will also compare overweight and healthy weight participants' networks (as groups) in this respect. The resulting networks will serve as fundamental input for the design of our intervention: by establishing that certain mechanisms in the network are dysfunctional and result in an eating event, we can both provide feedback of this in a suitable way and use predictions over time (i.e. changes in the network) to establish risk contingencies between the variables we assessed, as well as provide a 'warning' in the form of an intervention technique even prior to an actual eating event.

The SleepCare project (Beun, 2013) found that tailoring is extremely important for adherence to sleep-related interventions. It is necessary and possible to include an explicit alignment stage in automated mobile therapy. Levels of alignment are: communicative, therapy, ethical. It is also necessary and possible to include an explicit and frequent feedback loop in mobile therapy for various forms of adaptation. Negotiation improves user autonomy and can be built into mobile systems.

A.5 Existing products and devices that already incorporate tailoring

Intervention-related

The most closely connected products and devices that incorporate the principle of EMA are those that measure repeatedly over time. Commercial devices that do this are quite common for physical activity related interventions (pedometry and accelerometry), such as Fitbit, Jawbone, Nike's FuelBand, Philips' DirectLife, Apple's HealthKit, etc. One application that uses personalised feedback and tips as intervention techniques in combination with a website is the eMate: **http://emate.cs.vu.nl/**.

The clearest example of a commercially available intervention-related app is the Weight Watchers application, although the EMA protocol mostly centres on caloric intake and focuses specifically on food products.
Research-related

For conducting EMA research, there are a few prominent existing options available:

- PsyMate (**http://www.psymate.eu**), which is a commercial app (still in development) wherein a researcher can script an experiment.
- MoviSens (**https://xs.movisens.com/**), which is similar to PsyMate in that it offers a scripting environment and study management tools. This tool can also provide equipment for physiological measurements.
- iHabit (**http://emaresearch.org/ihabit/**), a freeware limited platform for running EMA experiments.
- SurveySignal (**http://www.surveysignal.com/**), which uses text messaging to ask participants to fill in questionnaires.
- ilumivu (**http://ilumivu.com/**), a powerful commercial interface for EMA research, including the use of physiological sensors. The ilumivu app can also provide feedback (as a form of intervention).

A.6 Relevance of research on this principle to Philips products and/or services

Given the demonstrated importance of tailoring health-promotion devices and strategies to users and usage contexts, Philips would do well to continue to integrate this principle into its product. And because tailoring requires accurate and constantly updated information about users and their contexts, extensive monitoring is needed. Relying on users to do this themselves, however, imposes an onerous burden. Self-monitoring is a tedious and error-prone process, given not only the demands of everyday life but also the tendency to confabulate. Offloading the burden of self-monitoring frees up cognitive and willpower resources and increases effectiveness (Gollwitzer, 1999).

Of particular interest to developers of multiple health-promotion products, such as Philips, is the potential for synergy across a range of domains. To take the example of DirectLife and Philips LivingColors: besides using EMIs to provide intervention-related techniques based on EMA data, part of such an intervention could come directly from adjustment of the environment itself (colour, lighting, scent, etc.). Contextual influences have been shown to be important in establishing behavioural change, so tailoring contextual changes through the use of Philips products could be a great asset. An example: frequently reporting headaches in response to questions in an EMA protocol could, provided it was programmed to do so, lead the intervention side of the protocol to communicate with in-house lighting and make the lighting emit softer hues. Or, if the data show that you feel good and eat fewer snacks when you are around other people, but you have not been to a particular friend's place in a while and are currently available, a Philips service could suggest that you plan an event with that friend, perhaps even in co-operation with him (i.e. involve multiple people). Additionally, if a tool such as DirectLife detects that you could use more exercise, the Philips service could suggest planning an event that includes physical exercise. It is important to mention that more empirical evidence is necessary before we are able to make any claims about the effectiveness of such additional therapeutic measures.

Trust in SleepCare

Helping sleep-deprived people to achieve better sleep quality. That is the aim of the SleepCare project Robbert Jan Beun from Utrecht University is working on together with colleagues from Delft University of Technology and University of Amsterdam.

The SleepCare training is offered through a smartphone app and is based on existing psychological therapy aiming at sleep restriction. In addition to tracking someone's sleeping patterns and advising on improvements thereof, people also get relaxation exercises varying from 1 to 16 minutes.

'Most people suffering from insomnia, stay in bed too long,' says Beun. 'We have to motivate them to get out of their beds, which contradicts their feelings. They are tired, they feel they need to rest. But research into sleeping disorders has proven that sleeping restriction helps to improve sleep quality.'

People can negotiate with the system about the timing and duration of sleep and exercises. That is important for the effectiveness of the training programme, Beun explains: 'For people to trust in such a virtual coach, several aspects are important. Establishing a feeling of autonomy, of being in control over their own daily schedule, is certainly one of those.' The training also needs to be tailored to the user, and needs to adjust itself to changing circumstances. Furthermore, expectation management is important, he states. 'You have to inform people upfront what they can expect. Yes, you will be even more tired at first, but after a week or two, you will be able to get a good night's sleep.' Also the look and feel of the app are very important to ensure trust. 'You need to build a consistent and attractive application. The language used should be not too difficult but also not too childish. And coaching messages containing typos or grammatical errors immediately decrease the faith in the entire programme.' Finally, the app should be transparent. Users have to be able to find information who or what company is behind it and what happens with personal information fed into the software. 'And last but not least: if the app cannot be operated in an intuitive way, people toss it aside very quickly.'

Principle B: Securing trust

This section covers principles of design for devices (and/or e-coaching) that establish and maintain the user's trust. How can the 'negotiations' between users and coaches best proceed? There are a variety of aspects to this question, including issues of product reliability and privacy protection, but we are considering it primarily as a matter of effectiveness and examining what research shows about how aspects of human-machine interface can ensure that users do not become dismissive of e-coaching recommendations. (For further discussions of ethical aspects of trust, in connection with respect for autonomy, see Principle E below.)

B.1 Key aspects of securing trust

As discussed in connection with 'tailoring' (Principle A), one common theme of the projects in the HLS programme is the idea that we measure and monitor people, and that we support people in changing their behaviour. We also want them to know things, to be aware of their thoughts and behaviour, and we support them in doing something – exercising, relaxing, concentrating, eating differently, or going to bed at a particular time. In some cases, we even want them to believe the opposite of what they believe (e.g. cognitive restructuring). This is not an easy matter; people's opinion and habits can be persistent and resistant to change.

The matter of changing an individual's beliefs and habits not only gives rise to an interesting ethical debate, but also influences the design of our coaching systems with respect to a relation of trust. Trust research in the information systems field has described trust as a primary predictor of technology usage (Li, Hess and Valacich, 2008; Muir, 1994).When trust is low, the potential to influence is low. People do not accept assertions or support from other people or from systems they do not trust. Building a relation of trust in our systems is, therefore, a mandatory effort in the design of our e-coaching systems. In order to give the user a sense of trust and improve the efficacy of our e-coaching systems, it is important that the systems ensure that a positive user experience is generated by reliable, safe, and trustworthy devices and services.

Trust typically refers to a situation characterised by one party (the trustor) who is willing to rely on the actions of another party (the trustee). Above all, trust is a subjective matter; different people view trust differently in different scenarios and have different magnitudes of trust towards the different trustees (Wang and Emurian, 2005). In what follows, we will refer to these parties as user or coachee, and system or (e-)coach, respectively; the actions may be physical or communicative. The coachee is uncertain about the outcome of the coach's actions or recommended actions, and evaluates expectations. In the case of our e-coaching systems, 'trust' implies that the coachee expects that the coach will observe safety rules and will provide recommendations that are in the coachee's best interest. Moreover, a coachee expects that the coach's assertions are truthful and that private information will not be revealed to third parties (see also Kool, Timmer and van Est, 2014).

B.2 The current state of research

Basically, we can distinguish between issues of input (from the coachee) and output (by the e-coach). Input information from sensors or from user actions pertains to issues such as authentication, confidentiality and message integrity (Cowley, 2012). 'Authentication' implies that the input information comes from the supposed user; 'confidentiality' implies that information sent over the network can only be read and altered by authorised users, such as a coach or coachee; 'message integrity' implies that the information has not been altered in transit. 'Output' pertains to the communicative acts from the coach; information such as assertions should be true and relevant; advice and recommended exercises should be safe, in the interest of the coachee, and adjusted to their individual needs and preferences. As trust is a subjective experience, we should make a clear distinction between reliability and perceived reliability. A communication channel can be reliable in the sense of the objective or

measured probability that messages can be distorted, but one bad experience by the user can be magnified in the user's mind, inflating the perceived unreliability of the system; in other words, trust comes on foot and leaves on horseback. It is therefore our task to ensure that the type of applications that we develop provide an optimal trust experience.

We will now present some of the variables found in the literature that may affect people's trust in electronic services. With some exceptions, most of the work presented below comes from overviews in trust research with electronic systems presented in Beldad, de Jong and Steehouder (2010), Wang and Emurian (2004) and Corritore, Kracher and Wiedenbeck (2003). It is important to realise, however, that the results were far from univocal and that most studies were conducted in the field of e-commerce. Here we will follow the classification presented in Beldad et al (2010), where three types of trust antecedents are distinguished: user based, medium based and organisation based.

User-based antecedents of trust pertain to the user's propensity to trust, and experience and proficiency in technology use. Some people simply are more trusting than others. There is no statistical evidence, however, that propensity to trust affects initial online trust in a company. It seems that the propensity to trust either facilitates the magnification or the reduction of the impact of website attributes as trustworthiness cues (Lee and Turban, 2001). The relation between Internet experience and online trust may be described as an inverted U: trust increases when experience increases, but at higher levels of experience, trust declines due to security and privacy concerns (Aiken and Bousch, 2006).

Medium-based antecedents are related to a broad range of issues, from information quality to the presence of another intellectual entity.

- Information quality pertains to the relevance, accuracy and clarity of information (see also Fogg, 2003). Messages should be free from grammatical and typographical errors. There is a strong effect of machine errors in automation (Lee and Moray, 1992), but if errors are predictable or workload is high, user have more confidence in the system. Recovery of trust can occur if the user is able to understand and compensate.
- Perceived ease of use and satisfaction with the system influences a feeling of trust. Trust increases with effective navigation, ease of searching for information and of carrying out transactions.
- Tailoring and personalisation of products and services to the target users improves trust (Srivivasan et al., 2002). A disadvantage of personalisation is that it requires the collection of personal information and, therefore, touches upon elements of privacy. (See section A above.)
- Graphical characteristics, such as proper use of visual design elements, professional images and overall look – and even colour and brightness – may influence a sense of trust. The results of graphical elements are less clear-cut, however.
- Explicit social presence increases trust and has a positive influence on the intention to participate in online interactions (Gefen and Straub, 2004). The effect of the use of personal photographs is less clear-cut and may invoke reactions ranging from suspicion to enthusiasm (Riegelsberger, Sasse and McCarthy, 2003). In other words, there is no simple heuristic on the types of photos that could increase online trust. Some results show that a virtual character is experienced as more trustworthy than a text-based assistant (Looije, Neerincx and Cnossen, 2010). An increase was also found in an experiment where an automated driving system mimicked the behaviour of the user in a display (Verberne, Ham and Midden, 2013). In addition, easy access to live customer representatives improves trust.
- Shared goals increase trust in automation technology. An experiment described in Verberne, Ham and Midden (2012) showed that an automated driving system that shares goals with the user is considered more trustworthy than a system that does not share goals.
- Explicit attention to ethical concerns such as risks, privacy assurances, security and safety issues have a positive influence on trust. Moreover, the involvement and guarantees of third parties and commercial interests of the system owner have positive effects on trust.

A decrease in trust may be caused by mixing advertisements with content, impolite error messages, poor website maintenance (e.g. broken links, outdated information, download problems) and instability of the system (e.g. long response times, frequent system downtime).

Company-based antecedents refer to the organisational reputation, perceived size of the organisation, offline presence and experience and familiarity with the online company. Personal experiences have an important impact on trust, e.g. satisfaction with previous transactions and familiarity. Trust is increased by positive ratings from members in a community and by the organisation's credibility in terms of actual fulfilment of their promises (Teo and Liu, 2007; Smeltzer, 1997). The perceived size of the organisation may have an influence, but other factors seem more important. Companies with offline presence are probably in a better position for their clients' trustworthiness. The effect of third-party quality certification or seals of approval is unclear, but good customer service and disclosure of knowledge about users have a positive effect (Corritore, 2003).

Trust in the e-Health domain Research on trust in the e-Health domain is dominated by the work of Sillence and others (e.g. Sillence et al., 2006). They present a three-stage model of trust. The first stage consists of a heuristic screening process in which sites are rapidly rejected on the basis of their design appeal. This is followed by a second stage in which users undertake a more careful content evaluation of the site noting, for example, authorship and credibility issues. The third stage consists of a process of longer-term engagement with the site through source integration and self-disclosure processes. Clearly, this is of relevance for long-term interactions such as therapies offered by our coaching systems.

Most of the research, however, discusses the role of trust in assessing health information offered via the internet (e.g. consumer health portals). Usually these portals contain a catalogue of health information, a search engine, a personalisation system and a network of communities (Luo and Najdawi, 2004). Many of them contain trust-building antecedents, such as information about their policies on privacy, security, editing and advertising. Editorial policies reveal the portal's practices on gathering, reviewing and updating health information; advertising policies address issues about, for instance, the guarantee of editorial independency and the nature of the business relationship between portal and sponsor. Other important aspects involve source disclosure (Web links, original research, edited information), ownership disclosure, third-party seals and branding. Bernstam, Sheltona and Waljia (2005) assessed 273 quality-rating instruments that health care consumers can use to assess websites displaying health information. It was found that only 29% publicly disclosed their criteria. In general, the criteria corresponded with those mentioned by Luo and Najdawi (2004). Adams (2010) also discusses how registration may undermine trust, depending on its purpose and how the registration is used. Another important aspect is presenting information in the user's own – and so-called 'plain', 'clear' or readable – language (e.g. Harris, Sillence and Briggs, 2011).

Seals of approval seem to be useful in theory, but users often fail to notice them when searching for information on websites (Adams, 2006; Eysenbach and Köhler, 2002). In the observational study described in Eysenbach and Köhler (2002), it was found that very few participants had noticed which websites they had retrieved information from and that none of them checked any 'about us' sections of the websites. In this respect, it should be mentioned that there may be an interesting discrepancy between what people say they believe is important when assessing credibility and what they actually do.

A contribution in the field of trust and health information that should be mentioned explicitly is the research presented in Harris et al (2011). The study aims at a factorial structure of a general measure of Web trust and a model that predicts trust in the advice found on health-related websites. To measure trust, questionnaires were derived from Briggs (2002), Sillence et al. (2004) and Sillence et al. (2006). The analysis revealed four factors: information quality (e.g. understandability), personalisation (e.g. tailoring), impartiality (e.g. impartial advice) and credible design (e.g. familiar logos). Variables specific to e-Health, such as perceived threat, coping and corroboration, added substantially to the ability of the model to predict the variance in trust.

Finally, the credibility and reliability of health information is addressed by the Health on the Net Foundation Code of Conduct (HONcode; http://www.healthonnet.org) and seems to be highly applicable to medical apps. In Lewis (2013) it is suggested that this system would enable registered developers to set up a (self-) certification process to highlight the fact that their app conforms to the basic criteria (with respect to confidentiality, information, purpose, justification of claims, contact details, and so on). Similar criteria are presented in Albrecht (2013).

B.3 Gaps and opportunities in the existing research

Traditionally, studies of trust have been dominated by discussions of whether the buyer trusts the seller, for example in e-commerce contexts. Relatively little attention has been paid to the trust involved in how buyers interact with their purchases, which is an issue of particular relevance in connection with e-Health products and lifestyle coaching (Beldad et al., 2010). In Human-Computer Interaction research, a broad spectrum of research topics on trust and security has been addressed, ranging from usable security mechanism to trustworthy biometric security (see e.g. HCI International, 2014), but the available studies on trust in e-Health are considerably limited. Moreover, the focus is primarily on interaction with websites, not on the design of smartphone applications; this is arguably due to the lag time between the emergence of new technologies, their uptake in healthcare, and the publication of relevant studies. On the other hand, it is likely that many trust antecedents presented in the previous section are also applicable in the e-Health and lifestyle coaching domain (c.f. Harris et al., 2011). In e-Health, however, people may respond differently to sites containing information and advice that they find unwelcome or threatening than how they respond to sites containing information they find congenial and comforting (Good and Abraham, 2007). These distinctive elements may not be captured by existing models of trust that have their origins elsewhere.

An important shortcoming is the lack of thorough theoretical underpinning of the empirical results and the absence of models that offer the information required to direct the design decisions in our applications. For instance, depending on the phase of interaction, it may be expected that some of the antecedents mentioned in Section B.2 contribute to a feeling of trust more than others do, and that high-quality independent advice plays a major role in the HLS projects (e.g. Harris et al., 2011; Sillence et al., 2007). Other unresolved questions are how contradictory information from sensors, virtual worlds and subjective experience should be managed (e.g. Fogg, 2003), how a feeling of trust influences positive therapy results (and vice versa), and how trust changes in the presence of a virtual agent. In Kamphorst, Klein and Van Wissen (2014), for instance, no difference in trustworthiness was found between virtual and a human coaching agent.

Another aspect that should be taken into account is that trust and honesty may have different meanings in different cultures. For that to be assessed, it is essential to understand the values and behaviour of the people in other cultures. A first exploration of trust in trade across cultures is presented in Hofstede et al, (2006), but to our knowledge there is no such research in the field of e-Health or lifestyle coaching. Here, again, we see the importance of the principle of tailoring.

B.4 Results and insights emerging in HLS projects

HLS research projects engage with the principle of ‘securing trust’ in four regards. First, trust needs to be secured in the context of pursuing the research, by ensuring that research participants are treated in a trustworthy way. Second, HLS projects have investigated ways of ensuring that data protection is reliable and protects privacy. Third, HLS projects have examined both ethical considerations regarding trust and the effects that perceptions of trust have on health promotion. Fourth, HLS projects have discovered elements of e-coach design which are important to improving a relationship of trust between e-coach and coachee. We will now briefly elaborate on these issues.

Research All projects refer to their academic affiliation on their websites, link to partners with a positive reputation (e.g. Philips, STW, NIHC), and include contact information (e-mail, telephone, researchers) to enable readers to get in touch with a live person to discuss any issues. Some projects mention the independency of the research and stress the non-profit context of the treatment. They also include information about the efficacy of the interventions, evidence-based techniques and consultation with experts (authority). An interesting observation was that the type of data processed may considerably influence the amount of energy spent on trust-related matters in the experiments. Assessment of clinical data usually requires more attention to trust than non-clinical data (e.g. disordered vs. non-disordered eating behaviour, or alcohol and drug abuse vs. sleep and activity behaviour).

In most of the experiments, participants are informed of the approval of ethical committees and sign an informed consent form that informs them about their rights as a participant. This consent includes, for instance, the goals of the study and the option of quitting the experiment at any time, as well as a confidentiality agreement from the experimenter. In general, registration for the experiments and the apps is password protected. Some projects also include privacy statements on their websites about data security, confidentiality and anonymisation of data, and the use of cookies. In some cases this information is included on the informed consent form.

Data protection In all projects, data security and protection are important requirements of the software architecture that gathers the experimental data. Subject data are indexed via an anonymised identifier and can only be accessed by the researchers. The research databases are placed on a dedicated server within the university's own secure network. Participants must give explicit approval for access to personal data (e.g. location, sleep, activity). In at least one case, data from the various sources are entered by using a server in a so-called 'demilitarised zone' (DMZ), a sub-network which is contained within the university network, yet completely separated from by a firewall which functions as a buffer. The DMZ can be reached from the internet, so the server in the DMZ can be used to host the registration website, send and receive mobile data, and distribute the mobile application itself.

Ethical considerations All projects recognise that trust plays an essential role in the conducted research, e.g. for the recruitment of participants and efficacy of (or adherence to) the various interventions (see McQuire, 1985). Experts on ethical aspects of e-coaching are involved at a reasonably early stage of the projects and guidelines from ethical committees (e.g. Medical Ethical Boards, Quality of Scientific Research Committee) are usually followed. In the PAIRS-project, the amount of time and effort put into the intervention of pregnant women and their partners, as well as the risk of poor birth outcomes, was taken into account. In the SleepCare project it was recognised that while the sleep restriction exercise is one of the most successful interventions in sleep therapy, the consequences of the exercise may be quite hazardous in some situations (e.g. risk of falling asleep while driving or operating machinery).

Trust relationship Apart from the issues above, several elements were mentioned that may improve a trust relationship in a coach-coachee interaction. We will summarise these elements below:

- Tailoring and personalising the intervention (see principle A)
- Paying attention to the language style used in the interaction
- Designing a consistent and attractive interface
- Including expectation management (e.g. safety warnings, temporary decline)
- Respecting the coachee's autonomy (see principle E)
- Giving feedback on behavioural choices and results
- Comparing results with other individuals
- Showing history of advice

B.5 Existing products and devices that already incorporate this principle

In Horsch et al. (2015), various types of sleep-related technology were evaluated with actual users, ranging from a simple alarm clock to sleep coaching applications. Ease of use, support, credibility and reliability of the sleep products were regarded as factors that contributed to the usage of the products. In general, products were easy to use and no prior knowledge was needed. Users did not doubt the reliability of the products, mostly because of the developer's reputation. Another reason for trust was that the information was consistent with other sources, e.g. the internet or earlier therapies (see also Adams, 2006).

At the same time, there seems to be a widespread lack of concern in consumer applications, ranging from the exercise to nutrition domains, with the other trust elements discussed in the previous section (see also Middelweerd et al., 2014). Many applications monitor the user's biosignals, such as heart rate and blood pressure, via built-in sensors in smartphones or wristbands. Despite the claims made by the developers of these systems, many of these measurements are unreliable. This presents no problem with respect to the perceived trust as long as the general public is unaware of this, but as soon as these results become public, the inclusion of sensors may cause a general mistrust towards systems that include sensor technology. To our knowledge there is no existing consumer application that discusses, for instance, the reliability of its own sensors. To put the previous discussion into perspective, it should be noted that it assessing the thousands of apps in the health domain on the issue of trust would require extensive research. And even if we were able to judge these principles from the manifestation of the interfaces, it would be difficult to unravel whether principles such as clarity of the message or graphical elements were intentionally included to improve the user's sense of trust.

On the other hand, within the European Economic Area medical apps must meet the requirements for safety, health, and environmental and consumer protection. So-called *CE marking* (formerly EC marking) is therefore a mandatory conformity marking for these types of products[12] and indicates compliance with the EU legislation for a product. If a product carries minimal risk, manufacturers can self-certify it by making a Declaration of Conformity and affixing the CE marking to their own product.

It is unclear, though, how CE marking will influence a user's feeling of trust now and in the future. First, CE marking is not a guarantee of the quality of the product or the clinical relevance of the diagnosis. Second, the effect that third-party quality certification or seals of approval have on trust is unclear (section B.2). Finally, like any other mark, CE marking can easily be misused and affixed to products that do not fulfil the European requirements and conditions.

B.6 Relevance of research on this principle to Philips products and/or services

We believe that the various trust elements introduced in the previous sections will be useful in any technology aimed at behavioural change. Coaching applications such as those developed and tested in the HLS programme require the collection of massive amounts of sensitive data (e.g. eating and sleeping habits, physical location) that should be handled with care. Communication about ethical topics, such as confidentiality and reliability, plays a critical role in these types of products and services (see also Compen, Ham and Spahn, 2014), and therefore the ability to communicate about these matters should be easily accessible to the user. It may also be expected that, because of their commercial interests, companies such as Philips have lower credibility than universities and that trust management may therefore play an even more prominent role in products from companies. In particular, the notions of 'trust', 'confidence', and 'credibility' play an important role in applications that promote activities and goals that by itself are not rewarding. For instance, sleep restriction requires a lot of willpower, in particular in the first weeks of the therapy, and can even be dangerous. A person performing these types of activities loses sense of direction and leaves the decision of whether or not to perform a particular exercise or assignment to the coach. Delays in positive therapy results can easily cause mistrust and should be handled with care and adequate expectation management.

12 The directives requiring CE marking cover a broad range of products, ranging from hot-water boilers to various types of health devices.

Attention to the principle of securing trust also has implications for ongoing project design, for example, for how coaching systems will manage inconsistent information (such as discrepancies stemming from sensor measurements and conscious user input), and how these inconsistencies will influence trust relations. Research is called for in this area, as these factors will play an important role in coaching applications where sensors are included. Finally, the health domain is a complex one and, since language use is an important antecedent for trustworthiness, attention should be paid to the legibility and reading level of textual information. It is our experience that professional support with consumer communication considerably improves the quality of these texts.

Finding the right cue

Within the Promoting Effective Intentions project Denise de Ridder from Utrecht University studies how people can reduce their tendency to procrastinate about health-related behaviours – in particular, the tendency to put off going to bed even when they had intended to get a good night of sleep.

'One of our most striking results was that people don't have a clue that they can formulate specific intentions. And if they do so, they are often not able to choose the right cues for themselves,' says De Ridder.

For example, if people intend to go to bed 'in time', they end up staying up later than they initially wanted. 'In research into intentions on eating behaviour, we have found that it can help to formulate more specific intentions, related to a cue.' Something like: if I am craving for a piece of pie, I will take a carrot instead. 'For bedtime procrastination, we expected this would work the same way. So if people would formulate intentions such as "As soon as Pauw begins, I will go to bed", we thought they would indeed follow up on their own intentions more. Surprisingly, in the case of bedtime procrastination, this turned out to be insufficient.' Therefore, the researchers aimed at introducing new cues, gentle reminders to people's own intentions given by the environment. 'We have introduced Philips Hue lamps as an extra, friendly reminder of someone's intentions. If the lamp turns into a specific, previously chosen, colour, or starts flickering, it is time to go to bed.'

Most apps are very good for gaining insight in one's own patterns and actions, De Ridder concludes. But the next step is the hardest: all well that you now have a record stating that you go to bed late every night, but how do you change this habit? 'We hope our research with the Hue lamps will show that introducing somewhat more external cues can help in this respect. And if so, hopefully that will be the basis for using electronics in a more creative way to nudge people in a friendly and non-pushy manner to support them in taking the desired action.'

Principle C: Preparing for moments of weakness

One of the key themes in recent research on self-regulation failure is the importance of anticipating situations in which intention-behaviour gaps loom large, and then taking steps to ensure that one can take advantage of beneficial automaticity. Implementation intentions are a prime example of this, as are strategies for making supportive thoughts available at critical moments (as in the case of cognitive behavioural therapy, CBT).

C.1 Key aspects of preparing for moments of weakness

Forming the intention to eat healthily or get more sleep is an important first step towards a healthier lifestyle. Unfortunately, good intentions rarely lead to lasting changes in behaviour. Despite their best intentions, people often end up eating that delicious-looking piece of cheesecake or watching 'just one more' episode of their favourite show at midnight. A meta-analysis of 422 studies with over 82,000 participants suggests that the strength of people's intentions is only a moderately good predictor of behaviour (on average, it predicts 28% of behavioural variance; Sheeran, 2002). Other research suggests that changing intentions only leads to a small change in behaviour (Webb and Sheeran, 2006), suggesting that people often fail to follow up on their good intentions. This phenomenon has been dubbed the intention-behaviour gap (de Ridder and de Wit, 2009; Sheeran, 2002).

There are two important causes of the intention-behaviour gap. First of all, people often form vague, unspecific intentions (Sheeran, 2002). For example, instead of planning to go to bed at 11, people merely plan to go to bed 'on time', leaving it up to their future selves to figure out the details. A second concern is that people often fail to anticipate which roadblocks stand in the way of goal attainment or which temptations are most likely to derail them. (As Principle A makes clear, there is a great deal of individual variation on this.) Specifically, people may be ill-prepared for moments of weakness, such as when their self-regulatory resources are depleted. Just as a muscle grows weary after extended use, people's self-regulatory resources can become depleted, making it more difficult to resist temptations (Muraven and Baumeister, 2000). For example, after sitting through a long and tedious meeting, or after getting an emotionally upsetting phone call, it will become more difficult to resist a tempting piece of cheesecake. Unfortunately, unless one's commitment to engage in consistently healthy behaviours is bolstered by behavioural strategies, one is unprepared for such moments of weakness, and the intentions are as ineffective as most New Year's resolutions.

In this White Paper we will focus on sleep and healthy eating, because these principles are extensively studied within the HLS projects. However, please note that the principles discussed here may also be applicable to other health-related behaviours.

C.2 The current state of research

There are several psychological strategies that can help people to overcome the intention-behaviour gap, such as implementation intentions and principles of Cognitive Behavioural Therapy (CBT). Implementation intentions are simple but powerful 'if-then' plans that specify when, where and how a person will act to fulfil a certain goal (e.g., eating more healthily, getting more sleep). For example, "If I feel like having cake, I will eat an apple instead," or "If I hear the *Top Gear* closing theme, then I will brush my teeth and go to bed." Implementation intentions are highly effective because the intended behaviour is automatically activated when the specified cue (such as the *Top Gear* tune or cake) is encountered (Aarts, Dijksterhuis and Midden, 1999). As such, people can hand control over their behaviour to the environment by using implementation intentions to help them prepare for moments of weakness. Implementation intentions have been proven effective in changing health-related behaviours, in particular those related to maintaining a healthy diet (Adriaanse, de Ridder and de Wit, 2009; Armitage, 2007; Chapman, Armitage and Norman, 2009; de Nooijer et al., 2006). A meta-analysis of 94 studies with over 8,000 participants suggests that people who form an implementation intention are much more likely to follow up on their intentions (Gollwitzer and Sheeran, 2006). Moreover, there is some research suggesting that the effectiveness of implementation intentions can be further enhanced by Mental Contrasting, which consists of imagining the positive future (e.g., looking good in swimwear) and obstacles that may be in the way of goal attainment (e.g., eating cheesecake when tired and hungry; Adriaanse et al., 2010).

Whereas preparations involving implementation intentions focus on the selection of situational cues (and specifically paired behaviours) that help you to respond appropriately when moments of weakness occur, cognitive behavioural therapy (CBT) takes a different approach by targeting an individual's dysfunctional thoughts and emotions. Traditionally, CBT has been used to treat severe psychopathologies such as depression, but recently researchers have started to use cognitive therapy (CT) and CBT to change people's consumptive health behaviours (Cooper et al., 2010; Corbalán et al., 2009; Göhner et al., 2012; Stahre et al., 2007; Werrij et al., 2009). Although CBT in general is heavily investigated and involves well-established protocols, the main principles of CT / CBT for helping people to close the intention-behaviour gap have not as yet been uniformly established. The general idea behind CT is to restructure thinking styles into being less dysfunctional and more constructive for achieving healthy behaviours and habits (Beck, 2005). In short, it seeks to reduce the impact of reasoning inferences that are based on overgeneralisation ("Bread doesn't make you fat"), the influence of authority / others ("It's impolite to refuse"), misinformation ("If I just avoid fatty foods, I won't gain weight"), logical errors ("If I throw away my food, it's disrespectful to poor people"), and so forth.

Often people are not aware of the extent of the beliefs they hold. The first goal of CT / CBT is therefore to raise awareness of dysfunctional cognitions that are most relevant to a client. This is achieved via the processes of collaborative empiricism, inductive reasoning and the Socratic method (Overholser, 2011; see Overholser (2010) for a more in-depth discussion of these concepts). Awareness of dysfunctional cognitions is raised through experimentation and exploration. Once a client is aware of dysfunctional cognitions (and behaviour), the next step is to reduce their influence. First, the impact of a dysfunctional cognition is investigated by the client by conducting empirical investigations in daily life and performing self-monitoring (e.g., via a diary) (Cohen et al., 2012). This is often quite revealing to a client, because it is a very tailored and relevant gauge of the impact of a dysfunctional cognition. Next, specific techniques (dependent on the issue being addressed and the phase of therapy the person is in) are used to gradually establish changes. An example of one technique used is consistently giving homework assignments relevant to specific phases and sessions within the therapy (Kazantzis, Zealand, and Ronan, 2000). The treatment protocol wherein these techniques are applied is compartmentalised into different phases or modules, depending on the specific protocol that is used. As an example, one very useful CBT technique involves the client conducting a 'behavioural experiment' to empirically test a dysfunctional belief they hold. For example, if this belief is that "I cannot refuse snacks at a party because it's rude and people will frown on me", an empirical experiment might involve refusing the snacks (after practicing with a therapist) and writing down how many party attendees responded unfavourably or showed non-verbal signs of disappointment or rejection. As noted in connection with Principle A, this involves extensive tailoring to individual circumstances.

C.3 Gaps and opportunities in the existing research

One shortcoming of the existing research literature is that it does not address how people can be coached to use implementation intentions or CBT to change their behaviours. For example, researchers have extensively tested the ways in which implementation intentions affect behaviours if these implementation intentions are of high quality. Unfortunately, the implementation intentions that people form unaided are often of rather low quality (de Vet et al., 2011), suggesting that many people could benefit from receiving help in forming appropriate intentions. HLS researchers are studying why people often form low-quality implementation intentions, and why they often procrastinate on forming intentions to change their behaviours (so-called 'second-order procrastination').

It is worth noting that one area in which much more research is needed is the personalisation or tailoring of these preparatory strategies. Effective preparation for moments of weakness involves identifying 'danger zones' and thus requires the sort of accurate and honest self-knowledge that is so difficult for most people to develop (see section A1 above.) The ThinkSlim app provides a good example of how assisted self-monitoring can enable users to identify the points at which they need to be especially alert.

The current research is also still limited in scope regarding domains of application. The effectiveness of behaviour change strategies such as implementation intention has been studied extensively with respect to a number of healthy behaviours, especially maintaining a healthy diet (as noted above). However, one blind spot addressed in the HLS programme has been research into interventions related to improving sleep-related behaviour. More and more people are suffering from a chronically shortage of sleep (Gallup, 2013), which is a risk factor for physical and psychological ailments such as chronic hypertension, obesity, diabetes, depression and cancer (Strine and

Chapman, 2005). HLS researchers are addressing interventions aimed at targeting bedtime procrastination, which has been defined as "going to bed later than planned without having a valid reason to do so" (Kroese et al., 2014; Kroese et al., in press). To combat bedtime procrastination, HLS researchers are studying interventions based on implementation intentions in combination with Philips Hue lights, which provide a nudge to help people follow up on their intention. A disadvantage of implementation intentions is that it can be difficult for people to identify a suitable environmental cue as basis for their implementation intention, and HLS researchers are studying whether, for example, Hue lights might provide a flexible, user-programmable and reliable cue for this purpose.

C.4 Results and insights emerging in HLS projects

Several of the HLS projects have been making significant advances in our understanding of the principle of 'preparing for moments of weakness'. As noted in section A.2, ThinkSlim is using risk contingencies for undesired/unhealthy behaviour as part of an ecological momentary intervention. Advances by Active2Gether are described below (see Principle D) and the SleepCare app includes key principles for introducing CBT planning (and feedback).

One research advance has come from identifying neglected domains in which Principle C applies. The 'Promoting Effective Intentions' project is the first to demonstrate that bedtime procrastination is a highly prevalent phenomenon (Kroese et al., 2014), thereby opening up the idea that sleep deficits are often behaviourally caused and thus amenable to the sort of interventions described in the present section. Like other forms of self-regulatory failure (e.g., failure to stick to a diet), bedtime procrastinators can benefit from behavioural change mechanisms. This is in stark contrast to the traditional approach to sleep research, in which sleep insufficiency is studied from a medical viewpoint. Unlike traditional sleep research, this research focuses on sleep deficiency in the general population. This finding has received extensive attention in the popular press, and has laid the foundation for research into possible interventions for bedtime procrastination.

C.5 Existing products and devices that already incorporate this principle

There are countless products and thousands of apps geared at improving exercise and eating habits. Most of these apps and products, such as Philips' DirectLife, Fitbit, HealthKit and Jawbone aim to strengthen intentions and help people to monitor their behaviour. These products and apps do not, however, employ the behavioural change strategies that are most suitable for preparing users for moments of weakness. These products often fail to make use of behavioural change strategies that are scientifically proven to be effective. They focus mostly on promoting self-improvement by making behavioural patterns visible, and by bolstering motivation. However, they often overlook strategies, such as the formation of implementation intentions, that can help overcome obstacles that threaten to undermine the process of behavioural change. Here, again, self-monitoring function is vital to success, and the market for sleep-monitoring devices and apps has grown rapidly in recent years. Where new research-driven developments can really make a difference, however, is in helping people to take advantage of these data (e.g., that someone procrastinates about bedtime more on Thursdays than on Mondays or that someone tends to 'treat themself' to an unhealthy snack after every meeting with their supervisor) for the purpose of developing effective behaviour change strategies.

C.6 Relevance of research on this principle to Philips products and/or services

If proven effective, behavioural change strategies can be applied in existing e-coaching applications (such as the DirectLife system) as well as new e-coaching platforms that are yet to be developed. These principles may also be employed in other products. For example, HLS researchers are studying whether light cues (e.g., through the Philips hue lights) can be used to strengthen the effect of implementation intentions in helping people combat bedtime procrastination. In the long term, wearables may help people to identify moments of weakness and prepare for them. Research on bedtime procrastination is also highly relevant for therapies and devices Philips is developing for addressing Delayed Phase Sleep Disorder, related to disruptions in circadian rhythms. All of this points to possibilities for rethinking the alarm clock as an integrated e-coach for promoting an effective plan for sleep, blue light exposure, and waking.

Engaging social networks

Within the Active2Gether project, Saskia te Velde and Michel Klein from the VU medical center and the VU University are developing an app which, in combination with a Fitbit activity monitor, motivates and empowers young adults to engage in more physical activity. The app contains an innovative adoptive system which involves the coachee's social networks to create and strengthen social support.

From previous focus group interviews it is known that most people prefer to share information about their physical activity only with a small group of people they know. 'In a trial starting later this year, we will invite students to test a prototype of the app,' says Te Velde. 'To identify existing social networks within the group, we will check their Facebook accounts for existing connections between them.'

Friends will be ranked, based on the strength of the friendship, their motivation to choose an active lifestyle, and their rate of activity in daily life. Participants can either receive messages referring to friends who are slightly more active than they are (upward comparison), or to slightly less active peers. An experiment proved that if the app adapts to the psychological characteristics of a person, for example whether someone wants to feel challenged, or on the contrary seeks confirmation, the follow-up of the given advise increases significantly. Within the project, another way to involve the social environment is considered, which is suggesting joint activities.

Built-in artificial intelligence enables the programme to adapt to changing circumstances. For example, perhaps a coachee at first needs to gain self-confidence, but later on needs to be motivated to maintain his level of activity. Every couple of days, the app reconsiders which coaching advise will be most effective based on the observed activity behaviour and input of the coachee, the changes in environment, and on the activities of the social network involved. 'Perhaps in week one it is best to compare ones activity with friend X, but based on his motivation, in week two friend Y will make the better peer,' explains Klein. The fact that the (social) environment is modelled as a dynamic factor, which is also evaluated and re-ranked periodically, is an innovative approach, which is expected to lead to a persistent increase of physical activity by the users.

Principle D: Engaging supportive (social) environments

Whereas principle C is largely about strategies that are psychologically internal, the focus here is on shaping the environment in a way that supports the achievement of health-related goals. Some of these approaches have to do with shaping the 'choice architecture' of how options are presented, but one particularly promising area of research relates to helping individuals to take advantage of the *social* environment, involving social contagion, social norming and social-network nudging.

D.1 Key aspects of the principle

Many theoretical models have been proposed that describe how (health) behaviours can be predicted (or changed) by a number of so-called behavioural determinants. he most well-known models are the Social-Cognitive Model (Bandura, 1986), the Theory of Planned Behaviour (Ajzen, 1991), the Health Belief Model (Rosenstock, 1974), the Health Action Process Approach (Schwarzer and Luszczynska, 2008) and the Self-Determination Theory (Deci and Ryan, 1987). . They all have some concepts in common and it can be argued that behaviour and behaviour change can be explained by three types of determinants, namely motivation, abilities and opportunities. Motivation relates to internal cognitive constructs, such as beliefs, attitudes and intentions. Abilities relate to someone's skills and knowledge, or their perception or confidence in their skills (i.e. self-efficacy). Opportunities relate to situational conditions that can be found in the physical and social environments, such as the availability of parks and bike lanes, or the presence of family and peers, or even policy regarding sport and food environments. This section will focus on the opportunities in the social environment, i.e. the situational conditions in the social environment and how these can be used to coach participants to develop a healthier lifestyle, i.e. being more active and eating healthily.

In order to study or manipulate physical or social environmental behavioural determinants it is helpful to categorise the different forms of environments. The ANalysis Grid for Environments linked to Obesity (ANGELO framework) is a helpful tool that distinguishes environments using a grid of two axes. The first refers to size, i.e. micro or macro, and the second refers to types, i.e. physical, economic, political, and socio-cultural. In the Active2Gether project, knowledge on these different environments is collected to either tailor the coaching messages to the specific environmental contexts or to cue supportive environmental factors to the participant. For example, knowledge about the availability of bike lanes (macro, physical), sports facilities (macro, physical), stairs and lifts (micro, physical) is needed in order to make the coaching messages personally relevant; we would not advise someone to ride a bike to work if there are no (safe) bike lanes or the distance to work is too far, and we would not advise someone to climb three flights of stairs if their building has only two floors. On the other hand, knowledge of facilities in the neighbourhood and stairs in the building, or physically active friends (micro, social), can help to prompt the participants to enter these environments and actively use them. Furthermore, the Active2Gether intervention not only uses prompting strategies, it also tries to change or re-shape social environmental factors and thereby trigger social influence.

Social influence refers to the ways people influence the beliefs, feelings, and behaviours of others. The social psychology literature usually distinguishes three types of social influence, namely, conformity, compliance, and obedience. Conformity refers to a change in beliefs or behaviours in order to fit in with a group and involves pressure from group norms, while compliance refers to a change in behaviour as a response to a request by another person or group. Obedience is responding to orders or commands without question because they come from a legitimate authority (this way of influencing people is not used in Active2Gether as it undermines feelings of autonomy). In addition, the physical activity literature distinguishes modelling, based on observation, as a specific type of social influence.

Compliance and confirmatory ways of influencing are studied and used in Active2Gether by making use of participant's social network (friends, colleagues) or by referring to populations to which they belong (e.g. university students, young adults). For example, Active2Gether studies the participant's network to identify

physically active friends and suggests that they play sports together. Or a closed (online) group can be created for members to formulate goals and support each other in achieving these goals. In addition, motivational messages are sent that provide normative or descriptive information about the sorts of things that people similar to them do or appreciate. Social influence can directly or indirectly affect health behaviour. The direct path will involve more automatic/unconscious processes, while the indirect path will involve changes in motivational determinants (beliefs, attitudes) that lead to changes in behaviour (e.g. physical activity). For example, Acive2Gether uses social comparison strategies to increase motivational factors that in turn lead to more physical activities. People in the participant's network can also be used to improve self-efficacy; if a particular person is similar to the participant, the participant might identify with that person and learn, through modelling, how to improve his/her own physical activity.

D.2 The current state of research

This section focuses on the use of networks. With the acknowledgement that the social environment is important for behaviour change, the challenge has been to find strategies that *use* the social environment to trigger behaviour change. Traditionally, interventions that are based on the social environment aim to find the individuals in the social network that can catalyse change in the whole group. For example, Valente and Pumpuang (2006) suggest strategies to find the influential individuals in a social network who are able to play an important role in achieving behaviour change in the group. These strategies focus on people with larger numbers of connections in the network, as their attitudes and behaviours may affect many others. The study by Groenewegen et al. (2012) investigated the effect of an online community in an intervention for increasing physical activity. It showed that the number of relationships in the community is not a predictor of physical activity, but that relations with physically active individuals are positively associated with higher physical activity levels. This affirms the usefulness of the strategy of aiming interventions at highly-connected individuals. Similarly, behaviour change strategies may focus on people with important connections. This is especially effective in strongly clustered social networks, in which influence can take place according to a sequence of cascades, where at each step a certain amount of time passes before a cluster is affected, following which, the next cluster is affected. The individuals that connect different clusters are called 'bridging nodes'. It is argued that they have more potential to act as a change agent and to adopt new behaviours faster than the rest of the network (Mollee et al., 2014). In Mollee et al. (2014) and Valente (2012), more can be found on the area of social network interventions.

D.3 Existing products and devices that already incorporate this principle

Many (health) behaviour change interventions are now available in the form of smartphone applications. As of October 2014, the number of apps in the 'Health and Fitness' category of the two main app stores is 39,687 and 36,964 (in the Google Play Store (Appbrain, 2014) and the iTunes App Store (148Apps.biz, 2014) respectively). Since the majority of the population owns a smartphone, 58% in the US (PewResearch 2014) and 67% in the Netherlands (GFK, 2014), these applications have a great potential to reach large numbers of users. To date, several content analyses have been performed to study the behaviour change techniques implemented in such health apps. In addition, a review and content analysis was performed within the Active2Gether project (Mollee et al., 2014). Given the special interest from the perspective of the Active2Gether project, the review was limited to apps that promote physical activity among adults through individually tailored feedback and advice. In the review, over 3,700 apps from the Google Play Store and iTunes App Store were screened for inclusion, and following additional assessment for eligibility, 57 apps were investigated in detail. The review process was guided by an adapted version of the taxonomy of behaviour change techniques developed by Abraham and Michie (2008). The adaptations comprised omitting three techniques because of low inter-rater reliability and further operationalising the remaining techniques (i.e., how these could be reflected in a smartphone application), as the taxonomy was originally developed for more 'traditional' behaviour change interventions. This resulted in a clear-cut coding manual, which two reviewers used to independently score the apps. The coding manual also includes behaviour change techniques that take the social environment into account and use groups or comparison with groups in order to make participants conform or comply with the group or the other person. An overview of the techniques with a social dimension is given in Table 1.

Table 1 | Overview of the behaviour change techniques with a social dimension.

No.	Behaviour change technique	Explanation
10A	Provide feedback on performance through social comparison with ranking.	The app indicates the level of the user's overall performance by comparing it to the performance of a group of other users.
10B	Provide feedback on performance through competing with others.	The app provides the option to compete with another user in a one-on-one challenge.
16	Provide opportunities for social comparison.	The app provides the option to participate in the same challenges as other users, and indicates the level of the user's performance in this challenge relative to the performance of other users in the same challenge.
17A	Plan social support or social change through possibility of linking with social networking sites.	The app supports the option of connecting to social networking websites, thus involving contacts from outside the community of the app in the user's health behaviour, for example by posting goals, achievements and workouts.
17B	Plan social support or social change through possibility to chat.	The app has a built-in chat function allowing users to communicate with other users in the app's community.

Table 2 shows the extent to which these socially-oriented techniques were identified by the reviewers in the set of 57 apps. It shows that some techniques are quite widely adopted, such as the connection to external social networking websites, but others very little, such as the direct competition with other users. Social support via online communities was also found to be the most commonly-implemented technique in another review and is extremely common in weight loss apps.

Table 2 | Extent of the socially-oriented behaviour change techniques in the reviewed apps.

No.	Behaviour change technique	Frequency	Percentage
10A	Feedback through social comparison with ranking.	12	20.34 %
10B	Feedback through competing with others.	4	6.78 %
16	Opportunities for social comparison.	15	25.42 %
17A	Social support/change through link with social networking sites.	23	38.98 %
17B	Social support/change through chat.	8	13.56 %

Although there is no consensus yet on the question of whether a larger number of behaviour change techniques is associated with a larger effect on the behaviour (Webb et al., 2010), some studies do report a correlation (Michie et al., 2009). Nonetheless, it is apparent from the content analysis conducted so far that there is still room for wider adoption of techniques that use the social environment or someone's network.

D.4 Gaps and opportunities in the existing research

One of the shortcomings in the existing research on social network interventions is that they usually aim for an effect at the group level, rather than applying a behaviour change method based on an individual's need. This means that the personal and behavioural characteristics of the individual are overlooked, and the optimal type of intervention may not be found. By taking the perspective of an individual user, the intervention can be tailored to his/her specific needs and wishes and can thus perhaps be more effective in achieving behaviour change. In addition, modern mobile technology allows for much more advanced socially-oriented behaviour change methods than the methods deployed in existing interventions. To put it bluntly, the current interventions seems to be lacking creativity when it comes to involving the social environment and using social influence techniques in attempting to stimulate behaviour change in an individual. One major limitation of the social features in existing

apps for behaviour change is that they depend largely on the initiative of the user. For example, the user is usually required to actively start contributing to a forum/chat, connecting to other users, entering a challenge with other users, or posting on an external social networking website. If the user fails to do so, the functionalities go unnoticed and the possible effect on his/her behaviour will remain absent. In addition, the possibilities for involving the social environment do not all fit users' wishes or preferences. For example, from the focus group study in Middelweerd et al. (2015) it emerged that potential users are not very eager to post goals, achievements or workouts on their social networking website. Furthermore, the behaviour change apps do not take interpersonal differences into account when it comes to deploying social features. However, some functionalities may be motivating to some users, while other users experience them as demoralising. For example, the extent of (de)motivation drawn from viewing a ranking of users may depend on the personality of the specific user regarding social comparison, as well as his/her position in the list. Finally, some ethical aspects of the use of social influence clearly need more attention, e.g., social pressure, feelings of autonomy, feelings of shame.

D.5 Results and insights emerging in HLS projects

Social networking sites are popular. Consequently, we assumed that creating a supportive online environment would enable us to increase levels of physical activity in young adults. Within the Active2Gether project, we now know that:

- Young adults do not like to post all of their physical activity accomplishments on Facebook. On the contrary, they state that those who post everything on Facebook are annoying. It is okay to share exceptional results, but not daily activities or sports accomplishments.
- Creating a private environment on social network site might be a possibility; a closed community where individuals can share accomplishments and experiences with peers.
- Young adults prefer a personal coach who supports them in becoming more physically active (e.g., emotional social support, providing instructions).
- Young adults prefer app features that target motivational/personal factors over those targeting social factors.

D.6 Relevance of research on this principle to Philips products and/or services

If Philips is interested in changing the behaviour of individuals and using the social environment to do so, the following issues are important to consider:

- Focus on private communities (e.g., within companies). We found that people are not willing to share their accomplishments with everyone, but prefer to share them within their own community or with friends (if at all). Focusing on programmes for specific companies or departments is therefore an attractive method.
- Exploit network structure interventions. People today are used to connecting with others within programmes, and Philips has health promotion programmes which allow this. Philips could therefore benefit from innovative methods of influencing people's beliefs and behaviour through their networks and connections.
- Work on virtual coaches with realistic emotions. We found that people prefer personal coaches, therefore virtual coaches should mimic real coaches as closely as possible. This can be done by tailoring coaching messages, but also by showing emotional responses. This requires the use of emotion models that can understand and generate human-like emotions.
- Focus on the personalisation and tailoring of advice. There is ample evidence that tailoring and personalisation increases effectiveness. This means tailoring to more than just current activity levels. Ideally, coaching messages should be tailored to the actual environment context, time, personal values and beliefs.

D.7 Take-home messages

1. Social influence can take different forms, e.g., conformation, compliance, obedience and modelling can all be used in healthy lifestyle interventions. However, this must be done with care, respecting the preferences and privacy of the target group, e.g. by creating a closed online network, and considering ethical issues such as social pressure, feeling of autonomy and shaming.
2. Social networks can be used to create social influence and provoke behaviour change. To this be done, an influential person in the network – someone with many connections and links to more than one cluster – must be identified.
3. So far, social influence has been implemented to a limited extent in mobile applications, most commonly as links to social network sites. Contrary to widespread perception, it seems that young adults prefer features that address motivational factors rather than features that address social factors.

Better self takes control

'People should be able to identify with an e-coach app, and recognise their better self in it,' says Joel Anderson from Utrecht University when asked about requirements for a successful mobile health application. Within the Healthy Lifestyle Solutions programme, he focuses on issues involving users' (sense of) autonomy.

Many people want to develop healthier lifestyles. They intend to go to bed sooner, or to lose weight. Mobile health applications can empower people to lead the life they want. To ensure a persistent change in behaviour, it is essential that people feel connected with such an app, Anderson states. 'Designers will have to make sure that e-coaching systems are perceived as partners, rather than bosses. People don't want to be bossed around all the time. Their autonomy has to be respected; what they ultimately seek for is empowerment to turn into better decision makers with regard to a specific health question.' This means that a mobile health app will have to represent the voice of the users' better self. 'The key is to design e-coaching systems that help you keep on the track you want to be on, even if you're resistant to the advice that your better self is giving you, via the e-coach.'

For people to feel comfortable in using an app to partly outsource something as personal as their better self, it is crucial that the app feels integrated into who you are, says Anderson. 'In a sense, the advice from the app should come across as coming from you – just from you in a well-rested, fully informed, and level-headed state.' This makes it pivotal that the user interface doesn't merely *allow* but actually *facilitate* customization during setup. The same goes for any peers you are compared with. 'Users need to be able to see people in their their support networks are sharing their values and goals.' And finally, designers need to build in regular moments of review, not only for a reality check on how well users are actually doing, but also so that users can assess whether or not adjustments are needed to the way the app is giving advice.

Principle E: Securing autonomy

A crucial factor in determining the acceptability of new technology – especially technology so intimately involved in the user's daily life, as in the case of e-coaching – is the sense that the technology doesn't take over. People want to be in charge, not controlled by something outside them. In this sense, they want autonomous control. At the same time, many users look to assistive devices, e-coaching, and even commitment mechanisms (such as locking the liquor cabinet) to allow them to regain control of their lives; that is, to strengthen their overall autonomy. In light of this, autonomy is a crucially important yet complex principle in the design of e-coaching systems.

E.1 Key aspects of the principle

This principle centres on a commitment to ensuring that health promotion strategies and technologies strengthen the sense in which users feel that they are in charge of their health, even while they are relying on e-coaching systems and other forms of support. There are actually two related but distinct sets of considerations here.

First, there is the value that many people attach to having a sense of autonomous agency, rather than being 'out of control' and at the mercy of their unhealthy urges and habits. For many users, at least, regaining a sense of control is as important as the resulting weight loss or improved vitality. In this sense, 'ensuring autonomy' means making sure that users of health promotion strategies and technologies are able to see the improvements in their health as largely their *own* accomplishment. The extent to which individuals value the experience of autonomy probably depends on the individual's personality [see Section A. on personalisation], the context [see Section C. on preparing for weakness], and the domain of life (e.g., one might have different attitudes towards one's exercise regime than towards one's medicine intake).

Second, the principle of 'Securing Autonomy' articulates the more specifically ethical concerns that arise when assistive technologies take over certain functions that would otherwise be performed by the person. An example of this is a support system that takes charge of planning one's schedule for the week. While this may seem innocuous, there may be issues with it for the follow reason: a number of philosophers have argued that people's capacity for making plans is a defining marker that sets humans apart from other animals (cf. Bratman, 1987). If we take this to be true, then the implications it has if people *outsource* their planning to an external system present an urgent question. This may sound like science fiction, but many of the situations in which e-coaching can help individuals involve keeping them on track when their judgment is affected by exhaustion, sleep deprivation, distracted attention, cognitive load, or emotionally 'hot' states. One can adopt various strategies – both high-tech and low-tech – for increasing one's chances of making it through the 'fog' of these situations without betraying one's goals and intentions. But frequently this involves relinquishing control at the moment of acting.

This second set of considerations takes on even greater urgency in cases in which the assistance we are being given involves other agents (including artificial agents). The issue here becomes one of ensuring that a minimum level of control by the user is safeguarded, to prevent violating people's rights to choose their own life paths without being manipulated or restricted without consent. For example, it may be argued that the outsourcing of planning is acceptable, so long as one has a viable option to override the system's plan. What is key is that relying on an e-coaching system doesn't end up putting one under the control of the system.

Although it is arguably up to individuals themselves to decide the extent to which they value autonomy in the first sense discussed above, the ethical constraints discussed in the second sense concern everyone. For what is at issue here is that e-coaching systems and other technologies express *respect* for the autonomy of each individual. Note, also, that this respect for autonomy is, in an important sense, an objective requirement in the sense that it can be violated without people noticing it, as when one's felt sense of autonomy is the result of manipulations

([see, e.g., Wegner and Wheatley's "I Spy" experiments (Wegner and Wheatley, 1999)). Moreover, there may well be limits here on the level of outsourcing permitted, even when users would like to relinquish more control.

Accordingly, the principle of 'Securing Autonomy' entails two distinct design principles. The first involves a process of determining whether someone is 'a person who values being in control', or, perhaps more accurately, 'a person who is in a context where s/he values being in control'. This might be done, for example, with a validated self-determination questionnaire (see E2). Interventions can then focus on supporting this experience of being in control, for instance by offering a high level of transparency to the user about *the reasons* behind a certain proposed measure (e.g., explaining why a breathing exercise would reduce stress) or by offering open-ended choice boxes (select A, B, C, or something else).

The second principle has more to do with the 'rules of the road' on how it is permissible to treat one another, with the related implications of sustained, intended *and* unintended use of a technology. Will a person become dependent on a technology? Does the user have a choice between similar technologies from a different vendor? How easy or hard should it be to switch? What freedoms does the user give up by using this technology, and what freedoms does the user gain by using this technology? On what basis do we decide whether the trade-off is personally, socially, and ethically acceptable? While the answers to these questions are essentially debatable and culturally dependent, formulating them will help in coming up with designs that minimise potentially harmful user-system interactions.

E.2 The current state of research

Literature on Self-Determination Theory (SDT) shows that, for many people, intrinsic motivation is an important force that helps people sustain their efforts in goal pursuit. Deci and Ryan (1987) have shown that "autonomy support has generally been associated with more intrinsic motivation, greater interest, less pressure and tension, more creativity, more cognitive flexibility, better conceptual learning, a more positive emotional tone, higher self-esteem, more trust, greater persistence of behavior change, and better physical and psychological health […]" (p. 1024, Deci and Ryan, 1987). These findings provide strong reasons to ensure that e-coaching systems offer autonomy-supportive conditions rather than controlling conditions. One striking outcome of the SDT research that is relevant for the design of e-coaching systems is that offering rewards might have an adverse effect, because rewards "tend to be experienced as controlling […], as rewards are typically used to induce or pressure people to do things they would not freely do" (p. 1026, Deci and Ryan, 1987). Another relevant finding is that intrinsic motivation is enhanced when people are given a choice. With regard to e-coaching, this suggests that offering more than one suggestion for action (for example for how to reach one's exercise goals for today) would be preferable over a single suggestion.

In discussions on ethics, philosophers have argued that autonomy involves people having a minimal set of positive and negative freedoms to make choices and give direction to one's own life. It means having the freedom to make and execute plans, as well as the right to be free from manipulation (e.g., Anderson, 2013). Stated in this way, at first glance it may seem that e-coaching systems do not qualify as influences that can infringe on these rights. However, without being strictly coercive, e-coaching systems can influence people in subtle ways that bring into question whether or not their autonomy is being respected. Examples include e-coaching systems that try to change how people value certain bad habits such as smoking, even if that means that a person who identifies with 'being a smoker' will have to give up that part of his or her identity. The concerns that arise in such cases relate to current philosophical research on the criteria for being autonomous (is it about *having* the capacities for autonomous choice and autonomous plan-making, or about *exercising* those capacities?). Moreover, it is related to questions of *authenticity*: when do we want to describe someone who outsources plan-making to an external system as an 'authentic' person, and when don't we? While current philosophical literature has many important things to say about (in)authenticity, autonomy, and the distinction between manipulation and 'mere influence', these questions have not been systematically addressed in relation to e-coaching systems specifically. Therein lies an important task, as the answers to those questions will, as indicated above, be important for the design of e-coaching systems that respect and secure autonomy. And answering these questions also involves anticipating

the possibility that people may feel estranged from themselves after following the guidance of an e-coaching system.

E.3 Gaps and opportunities in the existing research

Attempts to address the issues discussed above have been hampered by a confusing array of assumptions associated with the term 'autonomy'. What contributes to this – aside from confused claims from neuroscientists and journalists about autonomy not existing – is a widespread failure to distinguish between the experiential sense of autonomy on the one hand, and the ethical rules about protecting autonomy on the other. Authors often either lump the two ideas together – which tends to distort discussion, especially between different disciplines – or limit themselves to one, without addressing the other. This approach is no less problematic than the first, as it ignores the fact that interventions stemming from one set of considerations might directly impact the other (i.e., some forms of manipulation might be very effective but not acceptable, while some overly cautious precautionary measures might support autonomy but unnecessarily hinder effectiveness). One goal of the HLS project 'Promoting Effective Intentions' is to systematically keep the two sets of considerations distinct, while having each set feature in discussions about autonomy-supporting design.

E.4 Results and insights emerging in HLS projects

One development in this respect is that within the HLS projects, the self-determination questionnaires are being incorporated in experiment evaluations. In this way researchers are gaining insight into whether users find that the HLS e-coaching systems being developed are supportive of their autonomy or, conversely, they view the systems as external motivators that hinder their intrinsic motivation. In addition, the HLS SleepCare project has developed a sleep-coaching app that addresses concerns with alignment and autonomy by including a built-in component in which users have room to 'negotiate' with the e-coach on the extent to which they commit themselves to aversive (but needed) tasks, in this case, to activities that increase sleep quality. By actively engaging the user in the goal-setting process, the SleepCare app ensures that the user's goals are *aligned* with the system's goals.

A recurring theme across all the projects – in the research and implementation phases – is the challenge posed by striking a balance between two elements: on the one hand, if e-coaching systems don't offer users enough flexibility and leeway, they get annoyed or feel manipulated, with the result that they discontinue usage. On the other hand, if users have too many opportunities to fudge the self-reporting, adjust their goals, or make exceptions, they won't be able to take full advantage of the self-binding effects of e-coaching, which are often crucial to enabling them to gain control over their health problems.

On the philosophical side some conceptual progress has been made in separating the different ethical concerns that play a role in e-coaching systems. In Anderson and Kamphorst (2014), three groups of concerns are distinguished. First, there are concerns about violations of the integrity and dignity of the person. Second, there are social-political concerns, related to the social, economic, and cultural dynamics set in motion by the widespread use of pervasive computing for e-coaching. And third, there is a range of subtler concerns over how using e-coaching technologies may transform users' subjective experience and self-understanding. In another HLS paper, Kamphorst (2012) proposes several guidelines for safeguarding people's dignity and personal autonomy, such as:

- Delegation of control is valid as long as the delegator has ownership over the delegate, and the delegate offers the delegator a mechanism that is reliably responsive to control-retraction in a timely manner; and
- Delegated control is autonomy-respectful if and only if there is valid delegation of control over something that is autonomy-sensitive, and the delegate acts in accordance with the delegator's goals.

While these guidelines need to be developed further, they offer a starting point for implementing autonomy-supportive e-coaching systems.

E.5 Existing products and devices that already incorporate this principle

There are a variety of ways in which both aspects of autonomy discussed here are already being realised in existing e-coaching or health-promotion devices and services. With regard to the *experiential* sense of autonomy – the feeling of being authentically in control – this principle is implemented by showing clearly how users have reached their goals. In this sense, self-monitoring is crucial not only for course-correction but also for strengthening self-efficacy and the sense of authenticity. With regard to the *ethical* sense of autonomy, health-promotion apps, devices, and services typically incorporate this principle by securing consent for the use of sensitive data, and apps that involve human coaches thereby engage individuals who are subject to professional codes of coaching. In an automated context, however, this is not well developed.

E.6 Relevance of research on this principle to Philips products and/or services

As Philips develops e-coaching elements in its health-promotion devices, apps, and services, securing users' autonomy – in the experiential and ethical sense – is crucial to maintaining a reputation of trustworthiness and to ensuring that users feel comfortably in-control.

One example is a service like Philips' DirectLife. Incorporating SDT measures of autonomy-support could potentially increase effectiveness as well as people's perception of the system. Moreover, by reflecting on the ethical concerns that come with intensive digital coaching, possible issues with, for instance, vendor lock-in can be prevented by making people's data available in open formats. Similarly, ethical reflection may reveal the need to implement an opt-out 'destroy my data' button to ensure a minimum level of autonomy for users. Of course, these recommendations also apply to future Philips e-coaching products.

Similarly, a bedtime/wake time device that is designed to address Delayed Sleep-Phase Disorder (or promote better sleep, more generally), could benefit from close attention to how using the system can help users steer themselves towards earlier bedtimes (or less blue light exposure) without producing the annoying and alienating sense that "This damn app keeps bossing me around!" In this regard, one possibility is to use data from self-monitoring not only for course correction but also for underscoring one's sense of agency. Particularly interesting in this regard are the depictions of the progress users have made, which reveal how the use of the e-coach allowed them to successfully navigate situations of temptation and even temporary lapses of judgment.

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